

Integrated Waste Management Technology with Focus on the Brazilian Amazon

Valéria Arenhardt¹, Flávio de São Pedro Filho², Waldir Schalch³, Eduardo Egídio Vicensi Deliza⁴, Rodrigo Buss Back⁵

¹PhD in Environmental Technology from the University of Ribeirão Preto (UNAERP - Master in Business Management from the Vilhenense Association of Education and Culture, Professor of Entrepreneurship and Guidance for Research at the Federal Institute of Education Science and Technology of Rondônia IFRO. Member of GEITEC/UNIR, Brazil..

²Post-Doctor in Management and Economics from the University of Beira Interior, Covilhã, Portugal. PhD in Business Administration from the University of São Paulo, Brazil. PhD in Business Management from the Autonomous University of Asunción, Paraguay. Professor and Researcher at the Federal University of Rondônia, where he is Coordinator of the Management of Innovation and Technology Research Group (GEITEC/UNIR/CNPq), Brazil.

³PhD in Hydraulic Engineering and Sanitation from the University of São Paulo, Master's Degree in Hydraulic Engineering and Sanitation from the University of São Paulo, Graduation in Chemical Engineering from the Superior School of Chemistry Oswaldo Cruz, Coordinator of NEPER – Study and Research Center on Solid Waste. Works on technologies for the integrated management and environmentally appropriate disposal of solid waste, Visiting Professor at the University of Nebraska, Lincoln-USA (1999-2000), Professor USP/UNAERP, Brazil

⁴Specialist in Occupational Safety Engineering from Amazônia College (FAMA), Graduated in Mechanical Engineering from the Federal University of Technology, Paraná (UTFPR). Professor of Electromechanics at the Federal Institute of Education, Science and Technology of Rondônia (IFRO). Member of GEITEC/UNIR, Brazil. E-mail:

⁵Specialist in Management of Works from the Cuiabano Institute of Education (ICE), Graduate in Architecture and Urbanism from the State University of Mato Grosso (UNEMAT), Professor of Architecture and Urbanism at the Federal Institute of Rondônia (IFRO). Member of GEITEC/UNIR, Brazil.

Abstract— *This study deals with the management of the specific residues of tires, electro-electronics and batteries in a city in the Brazilian Amazon. The goal is to propose sustainable actions for the residues under study and, using SWOT analysis, to build a prognosis capable of contributing to environmental, economic and social sustainability. The specific objectives are: (1) Characterization of the hazardousness of the waste under study and the responsibility for its management; (2) identification of actions and goals in the management of specific solid waste; (3) use of the SWOT matrix to identify the positives and negatives in the waste management under study; (4) propose actions and goals to combat the problems encountered. The choice of sample was purposely directed to the public managers directly involved in implementing the plan with a focus on the residues under study. It is an exploratory descriptive study, mixed I character and with qualitative results. The result points to problems that demand immediate and urgent solution suggestions are made for actions and aims with immediate effect. These actions would enable entrepreneurs to optimize sustainable social and economic development in the Amazon. This study may benefit business owners, governments and other institutions interested in specific waste-related issues.*

Keywords— *Amazon. SWOT Analysis. Specific Waste. Sustainability.*

I. INTRODUCTION

One of the main challenges for Brazilian municipalities is the management of urban solid waste. It should be recognized that enough reusable waste is disposed of each year in the world to have a major environmental impact, for example on the pollution of water, soil, or air or the endangering of the planet through the contamination of plants. Planning actions to minimize the amount of waste disposed of on land or in the sea will ensure a more sustainable planet for future generations.

To strategically plan for an environmentally efficient and effective management is the intention of the present study; it does so by analyzing the plan of aims and actions for specific solid waste in the Municipality of Vilhena located in the region of the Brazilian Amazon. The main income of the Municipality, which according to IBGE (2017), has an estimated population of 95,630, comes from commercial and service activities, but industry, agriculture and horticulture are gaining greater prominence in its economic growth. Research shows that the collection of municipal solid waste is carried out by the city council in trucks that, since May 2014, have taken

their loads to a place where the waste is sorted and the tailings sent to be stored in a prepared landfill site. Before 2014, the city, like many other Brazilian cities, had an open dump. The municipality has not yet implemented selective household collection.

II. OBJECTIVES

This work proposes sustainable actions for the waste under study using a SWOT analysis to identify positive and negative points in the management of specific waste. It seeks to propose a plan capable of contributing to the pillars of environmental, economic and social sustainability in a municipality in the Amazon region of Brazil. Its specific objectives are: (1) classification of the hazardousness of the waste under study and responsibility for its management; (2) identification of actions and goals in the management of specific solid waste; (3) use of the SWOT matrix to identify the positives and negatives in the waste management under study; and (4) proposing actions and goals to combat any problems encountered. The sample was purposely restricted to the municipal managers directly involved in the execution of the plan, focusing on the waste under study. This is an exploratory descriptive study, of mixed character and with qualitative results. The question to be addressed is: What actions are possible for a municipality anxious to send the waste under study to the most suitable destination? The result points to problems that require urgent solutions and suggests actions and targets for waste that can be implemented at once. The actions indicated would enable entrepreneurs to optimize sustainable social and economic development in the Amazon. This work may benefit business owners, governments and other institutions interested in specific waste-related issues.

III. LITERATURE REVIEW

According to Luiz *et al.* (2015), there is an environmental crisis due to the inefficient execution of public policies for disposing adequately of specific waste. In a study, the same authors point out that the State of Rondônia, in the Brazilian Amazon, presents sad statistics of concentrations of solid waste in open dumps in several municipalities. This shows the fragility of the country's social structure with reference to solid waste management. Such a scenario demands immediate solutions in the municipalities of the region to the problem of the best destination of specific waste, for example, tires, electronic devices and batteries. Brazil's inadequate management of specific solid waste suggests national and not only local consequences, which allows us, by means of epistemological studies, to suggest actions that might alleviate its current predicament.

3.1 Characterization and hazardousness of the waste under study and reuse technologies

The Brazilian Association of Technical Standards – ABNT, through the NBR 10.004/2004, classifies residues on the basis of their potential risk to the environment and public health, indicating which must have more strictly controlled handling and disposal.

a) Waste of disposed tires

According to a study by Bertollo, Fernandes and Schalch (2002), tires are classified as Class II A – non inert – because of the levels of metals they contain (zinc and manganese) in their solubilized extracts, which are higher than the standards established by NBR 10.004/2004. Abandoned or inadequately disposed of unserviceable tires constitute an environmental liability, which results in a serious risk to the environment and public health. For this reason, even before the approval of the PNRS, tire manufacturers and importers have been since 2009 required to implement reuse technologies; they must collect and dispose of waste tires in compliance with CONAMA Resolution No. 416 of 2009.

b) Electronic waste

The classification of WEEE-Electrical and Electronic Waste recalls a norm established in the NBR 10.004 of 2004 of the Brazilian Association of Technical Standards – ABNT, in which Annexes G and H classify as non-hazardous such residues as polymerized plastic, scrap non-ferrous metal (brass etc.) and rubber waste. Given these stipulations, electronics may be said to fall into the non-hazardous category, although according to Pnuma (2010), electronic waste includes plastics, metals and other elements, which require specific technologies and suggest that electronics may be hazardous.

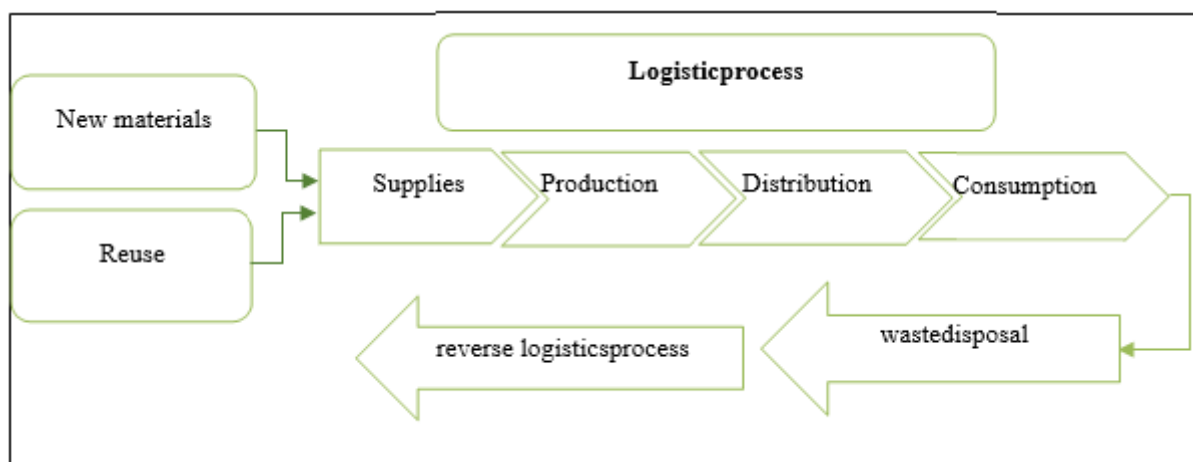
c) Spent batteries

The CONAMA Resolution 401/2008 insists that establishments selling batteries must contain adequate discarding points and promote reverse logistics for spent batteries, establishing the toxic limits contained in batteries and also the criteria for their commercialization in any country. Machado (2013) states that batteries can contain toxic metals which in the long term can be very harmful to the environment. He emphasizes that there are alternatives for their disposal, such as the recycling of parts or materials in cells and batteries. According to Mesquita *et al.* (2015), the risk with batteries is their endurance in the environment, especially in soils and groundwater; they have great potential for environmental destruction and do not degrade over time but remain in the ecosystem where they are deposited.

3.2 Shared responsibility for the management of specific solid waste

The Brazilian legal norms for solid waste are found in the National Solid Waste Policy – PNRS, which prioritizes the non-production, reduction, reuse, recycling, treatment and adequate final disposal of waste. The same rules establish a series of obligations for generators and public authorities to enforce the management of waste produced in a company. These obligations include the preparation of Municipal Plans, a compulsory condition, imposed on municipalities under penalty of non-access to federal resources of the Union (PNRS/BRASIL, 2010). Soares *et al.* (2016) point out that, despite the imposition of

restrictions, only 41% of the 5569 municipalities had drafted their municipal solid waste plans by the end of 2015. Manufacturers, importers, distributors and traders of the waste under study are also obliged to take all necessary measures to ensure the implementation and operation of the reverse logistics system (the model is represented in Figure 1), involving the return of waste generated by consumers, the purchase of used packaging, the provision of waste discarding points and working in partnership with cooperatives and associations of collectors to enable this waste to be sent to the most suitable destination.



Picture.1: Reverse logistics

Source: Authors' Construction

The reverse logistics process requires procedures and investments capable of effecting actions from the manufacturing of goods to the consumption and return of the waste generated for reuse in the manufacturing process or even in appropriate disposal, observing the composition of the residue. Table 2 describes the procedures in the trajectory to effect reverse logistics.

Table.1: Manufacturing process, reverse logistics and reuse of materials

Logistic process	The process of returning the materials, after the use of specific residues, that must receive treatment by the manufacturer, due to their composition. These can be reused with their own technologies.
New Materials	Those produced by manufacturers who know the composition and technologies used.
Supplies	Place where the materials and technologies are located that will be part of the manufacturing process
Production	The process of transforming the materials with private technologies
Distribution	After the transformation, the product is ready to be distributed to the dealers, to reach consumers
Consumption	The consumer uses the material/product until it no longer has a use.
Discard	Process for the disposal of waste materials
Reverse logistic process	Pickup process to send to the manufacturer who will forward it to the correct destination
Reuse	Process of reuse by the manufacturer, where the waste enters the productive process again, obviating the use of new natural resources.

Source: Authors' Construction

3.3 SWOT Matrix Concepts

Strategic planning is the process of defining strategy, direction and decision making for the allocation of resources, including capital and people. SWOT Analysis is a strategic diagnostic tool integrated into the process of continuous improvement that facilitates the evaluation of a particular area. It reflects a global perspective on the situation of a given organization, allowing improvements to be identified, and helping strategy to be defined (UNEP, 2009). According to Silva (2009), the SWOT Analysis

tool, divided essentially into Internal Environment Analysis and Analysis of the External Environment, proposes that, from the mapping of Internal Strengths and Weaknesses and also from External Opportunities and Threats, those responsible for creating strategies will gain have the necessary resources to take full advantage of Opportunities and Strengths, minimizing or even eliminating the Weaknesses and Threats that impede the advent of solutions to the problems identified (see Figure 2).

Internal (Organization)	Forces	Weaknesses
	They are advantages that the company has in relation to competitors	These are the competencies that are under the organization's influence, but somehow disrupt or do not generate competitive advantage
External (Environment)	Opportunities	Threats
	The forces that positively influence the organization, but over which it has no control.	These forces do not exert influence, but they weigh negatively on a company. They can be considered as a challenge imposed that can reduce its ability to generate wealth.

Picture.2: SWOT Matrix Model

Source- Adapted SILVA, 2009

IV. METHODOLOGY EMPLOYED IN THE RESEARCH

The present work was developed on the basis of the Municipal Integrated Solid Waste Management Plan of Vilhena (PLAMRESOLV), which provides for the management of urban solid waste in a city in the Brazilian Amazon. Exploratory qualitative research on the legal norms was carried out in a bibliographical study of the action plan and the targets, diagnosis and prognosis for waste tires, electrical and electronic equipment and batteries; and a field survey for a case study to identify the actions implemented and the goals reached from 2014 to October 2017. The SWOT matrix was used to identify the internal strengths and weaknesses, external opportunities and threats to the waste under study. The instruments used were questionnaires answered by the public agents responsible for implementing the plan and those who coordinated the activities related to such waste. The landfill was visited by the agents who segregate the waste. Data were collected in October 2017 and the respondents in the sample were selected specifically

because they are directly involved with the actions and the residues under study and represent the local municipality.

V. RESULTS OF THE RESEARCH

The results of the research bring a diagnosis of the actions and goals foreseen in the Municipal Plan of Integrated Management of Solid Waste of Vilhena, the municipality under study, as well as a SWOT analysis of the specific residues of tires, electric, electronics and batteries. The study ends by suggesting actions which might contribute to the social, economic and environmental sustainability of the Amazon region of Brazil.

5.1 Diagnosis of the actions and goals in the management of specific municipal solid waste in the period from 2014 to 2017

Table 2 presents information for analyzing the goals and action plan. No plan compares the deadlines established by the municipality with the evidence contributed by the municipal managers.

Table.2: Actions and targets for waste under study and search result

	Actions and deadlines foreseen in the municipal plan. Waste from Reverse Logistics (Tires, Electronics, and Batteries) Year 2014	Evidence from questionnaires Month of October 2017
Action 1	Creation, reproduction and distribution of informationsheets	The municipality claims to have published information sheets but there were distortions in the population's understanding, and so they were immediately reorganized.
Goal	Disclose clearly and objectively to consumers the procedures for disposing of such waste and also inform and guide entrepreneurs about the regulations and procedures for collection, transportation and final destination of reverse logistics waste.	
Deadline	02 YEARS	
Action 2	Create a register of establishments involved in reverse logistics.	No information was obtained on this action.
Goal	All establishments whose waste can be treated by reverse logistics must register with the Municipal Environment Department, indicating, when necessary, the name of the technically qualified person responsible for waste management.	
Deadline	05 years	
Action 3	Creation and implementation of municipal law dealing with waste from reverse logistics.	Up to the present, no law has been passed regulating reverse logistics in the municipality.
Goal	Create the Municipal Law based on Federal Law 12,305/2010 regulating reverse logistics in the municipality.	
Deadline	02 years	
Action 4	Regulate the reverse logistics system	No information was obtained on how supervision works. According to the evidence, the partnerships for shared responsibility are informal only and have not been formalized.
Goal	Regulate and supervise reverse logistics, in order to organize the enterprises that are included in this system, defining the procedures for collecting such waste and establish shared responsibility, including procedures in environmental licensing.	
Deadline	05 years	
Action 5	Establish Sector Agreements.	-The municipality with the Public Prosecutor's Office "charges" the entrepreneurs' actions based on the National Policy. -According to information, the Municipality formalized some agreements for sending some waste products, such as tires, to the correct destination.
Goal	Seek cooperation between the Municipal Public Power with the business sector and other segments of society, through clarifications on the structuring and implementation of the issues involved and through material and technical support to put the legal provisions into effect.	
Deadline	05 years	

Action 6	Establish VDP-Voluntary Delivery Points	-There was an initiative to send electronic devices to delivery points, mobile "carts" that took them to a deposit in the City Hall for some future destination. -For batteries, there are two privately runeco-points -For tires a local (municipal) deposit was created to receive such waste from the generators.
Goal	In partnership with merchants,create, voluntary delivery points (VDP) for the temporary accumulation of special waste, since the law obliges retailers to make servicesfor receiving such waste available to consumers.	
Deadline	05 years	Ongoing

Action 7	Discipline and intensify supervision of enterprises	
Goal	Discipline the activities of generators, transporters and waste receivers, requiring management plans as appropriate, inspecting the establishments within the Reverse Logistics System, issuing declaration of compliance with the National Policy on Solid Waste	The plan now in progress will be reformulated and the activities of generators, transporters and waste receivers will be disciplined.
Deadline	Not determined. Continuous program as of the 2nd half of 2015.	In permanent execution

Action 8	Conduct educational campaigns.	
Goal	Hold encounters and meetings with bodies representing the sectors in the reverse logistics chain to discuss, clarify, debate, find solutions and campaign in partnership with the companies to collect the waste that can be sent to a final destination.	Work is being done with schools, companies and entities; this should be expanded.
Deadline	Not determined. Continuous program as of the 2nd half of 2015.	In permanent execution

Action 9	Restructure tire shed.	
Goal	To carry out the necessary maintenance as well as improvements of the existing structures for the good operation of the shed holding waste tiresfor collection, since it is not in the best state of conservation.	This action is foreseen, but not yet performed due to lack of financial resources. Note that the site still supports the demand.
Deadline	06 years	Planning for implementation - budget forecasting

Source: PLAMRESOLV (2014) and Authors of this research (2017)

5.2 SWOT analysis of the waste under study

The SWOT analysis points out positive opportunities and strengths as well as negative threats and weaknesses in an internal and external balance, taking into account the Municipal Plan for the Integrated Management of Solid Waste of Vilhena- PLAMRESOLV. The National Solid Waste Policy establishes that the waste under study

requires reverse logistics through sectoral agreements between public entities, manufacturers and traders. Table 3 identifies the internal and external positive points – strengths and weaknesses – as well as the external opportunities and threats found after the bibliographical and field research with the municipality on the actions and targets for waste tires, electronics and batteries.

Based on this analysis, some strategies were proposed to minimize the weaknesses.
maximize the strengths and opportunities while

Table.3: SWOT Analysis for Tires, Electronics and Batteries waste

	Positive	Negatives
	Strength (S)	Fragility (W)
	<p><u>Common to all waste under study</u></p> <ul style="list-style-type: none"> -The waste is foreseen in the municipal plan and plan of actions and goals - There are initiatives to install the VDP- Voluntary Delivery Points for some waste. - The creation of a segregation cooperative in the landfill is encouraged. <p><u>Tire Waste</u></p> <ul style="list-style-type: none"> -There is a public space (shed) to hold the waste. -There is a partnership for the disposal and incineration of waste. - There are human resources and materials for receiving it. - The cost of the transportation company contracted for incineration was assumed. <p><u>Electrical and Electronic Equipment waste</u></p> <ul style="list-style-type: none"> - The VDP (Voluntary Delivery Point) and collection with simple mobile vehicles are in use. -The definition of conditions and public space (Shed) for the disposal of waste electrical and electronic is in process. -The disposal of electronic waste is being studied. <p><u>Battery Waste</u></p> <ul style="list-style-type: none"> - There are initiatives to install PEV-Points of Voluntary Delivery. 	<p><u>Common to all waste under study</u></p> <ul style="list-style-type: none"> - There is no planning or publicity of the actions goals, responsibilities, dangers, initiatives and sanctions for the agents who must be involved in the collection and destination process. -Lack of policies to encourage and educate the population in waste disposal, with clear aims for generator/consumer attitudes and behaviour -Lack of a Reverse Logistics municipal law -Selective household collection is not effectively implemented - The sectoral agreements are informal. - There is no comprehensive environmental education plan or action plan for the general population. -There are too few partnerships and training incentives for the use of waste andfor entrepreneurial reuse projects. <p><u>Tire Waste</u></p> <ul style="list-style-type: none"> -The location of a delivery point/collectionis not appropriate -There is no collection for small generators - Too little initiative has been shownin the transportation for small enterprises. <p><u>Waste Electrical and Electronic Equipment</u></p> <ul style="list-style-type: none"> - It is not predicted in actions and goalshow and when this waste will be reused, inertize and/or recycled. - Electronic devices are not separated from other residues in people's homes. - Waste is collected by simple mobile vehicles in public spaces, but it has no destination. <p><u>Spent Batteries</u></p> <ul style="list-style-type: none"> - These are not separated from other kinds of waste in people's homes. - There are only two collection points for them. - Despite legislation, resellers do not feel obliged to collect after use. - There is no definite destination for this waste.
	Opportunities (O)	Threats (T)
External	<p><u>Common to all the waste under study</u></p> <ul style="list-style-type: none"> - Develop a positive and sustainable image by means of advertising. -Create clear information targeted at the population 	<p><u>Common to all waste under study</u></p> <ul style="list-style-type: none"> -Ground pollution -Pollution of water resources -Air pollution

	<p>encouraging positive action</p> <ul style="list-style-type: none"> -Create a municipal law for reverse logistics. -Involve dealers and manufacturers -Create legal norms guiding the actions of the population in separating and treating waste correctly and sending it to the right place. -Introduce domestic selective collection -Make an environmental education plan with actions and goals that can reach the entire population -Create legal norms to inform the amount of waste generated in the municipality. - Formalize partnerships and sectoral agreements. -Propose partnerships with neighboring cities for effective actions. - Encourage the implementation of small enterprises. Generating employment and income through the implementation of reuse. 	<ul style="list-style-type: none"> -Actions with damaging results due to lack of information -Sending waste to locations that are not suitable for generators -Difficulty in identifying the VDP (Voluntary Delivery Points). -Difficulty of separating waste in people's homes and segregating waste in the landfill, owing to contamination.
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Source: Prepared by the authors

The result of the SWOT analysis points to viable actions contributing to social, economic and environmental sustainability that should be carried out immediately. Actions should have feasible goals summarized as legal norms, involving the people who are part of the waste generation process; the legal norms and disclosure should underline the rules so as to reinforce the commitment to sending waste to the most suitable destination.

The positive actions of the municipality should be highlighted, for example, the initiative in the partnerships arranged for the creation of the Voluntary Delivery Points-VDP, as well as the creation of cooperatives for the segregation and correct destination of waste.

The weaknesses found are lack of planning, of public policies for reverse logistics, and of publicity with clear and objective information, together with the improper disposal of waste, the need for selective collection; they should all be interpreted as opportunities to involve the powerful and the generators of waste to commit themselves to its disposal.

The opportunities found are to act through an environmental education program to create means to control the generation of waste, formalize partnerships with neighboring municipalities to minimize the costs of destination, with SENAI and SENAC to propose training courses for the reuse and recycling of this waste and with SEBRAE for business plans and economically profitable management.

External threats are the contamination of drinking water and the sources of soil and air. The study points to threats such as inadequate pipelines from generators that dispose of electronic devices on the street, at roadsides and in rivers, tires that are buried and burned, batteries that are included in household waste without proper separation: these are all totally inappropriate ways of dealing with waste. Another threat is that the PVDs, are not identified which makes it difficult to locate where specific kinds of waste are received. It should be emphasized that failure to separate residues in households and businesses in landfills often contaminates them beyond use.

5.3 Actions and goals proposed for these waste products to combat present problems

The above SWOT analysis identified that the municipality did not assess the gravimetric composition for obtaining the type and quantity of waste generated in the municipality. According to the survey, no study has been made of the amount of waste generated in the municipality, which leads to difficulties in proposing actions and targets for subsequent years. With this in mind, taking theoretical studies into account, actions and goals have been proposed to minimize the threats and weaknesses found in both the plan and the local research. Table 6 presents suggestions for actions and targets for this municipality's waste derived from the SWOT analysis and the findings about the municipal plan.

Table.4: Targets and actions for waste under study

Waste in this Municipality – Actions	
Actions and technologies to reduce the internal fragilities found	
Internal	<ul style="list-style-type: none"> -Create a municipal law for reverse logistics and partnerships to allocate funding for the accommodation and transportation of waste and sufficient staff. -Institute legal norms to regulate the behaviour of the generators, traders and consumers involved in the process, with clear definitions of each group's responsibilities. -Introduce selective collection of waste in people's homes. -Include in the Plan more concrete actions and targets for the reuse, recycling and disposal of waste using existing technologies and as practiced in other municipalities. -Study means of direct communication with the population that can guide, raise awareness and inform about the importance of sending residues to the correct destination and of the implications for health of the contamination of water, soil and air, breaking down current paradigms and compromising to take innovative action. -Define the correct destination of waste, in particular, batteries and electronic devices by means of partnerships and the removal of such waste to places where its components can be used. - Encourage SEBRAE/SENAI/SENAC partnerships and commitment to a business plan, training in dismantling and separation and thus the emergence of new enterprises capable of generating employment and income through the use and reuse of waste by means of available technologies. -Create control and survey systems for consumption by the municipality through links on the city's website where manufacturers and resellers can periodically post the quantity of sales made. -Identify and expand local Voluntary Delivery Points and/or provide transportation to collect waste in the peripheries, especially in small enterprises/generators.
Goal	Immediate Initiative
Actions and Technologies to Reduce External Threats Found	
External	<ul style="list-style-type: none"> - Prepare the population for inspection, to eradicate the inadequate disposal of waste. - Disseminate, inform and raise people's awareness about the danger to human health and negative impact of waste electrical and electronic devices when they are improperly disposed of, highlighting the pollution of soil, water and air. - Control the sale of products so that the quantity of waste generated can be identified, making possible the monitoring and inspection of its destinations. -Create legal rules with fines for those who dispose of waste improperly.
Goal	Immediate Initiative

Source: Prepared by the authors

With the actions and goals proposed for the waste under study, it is suggested, the impact on the environment by inadequate disposal will be minimized and all those involved will be able to consciously participate in consolidating the national policy for solid waste and thus promote economic, social and environmental sustainability. It must not be forgotten that the greater part of the residues under study are not bio-degradable and that inadequate disposal can irreparably damage the environment.

VI. CONCLUSION

All the methodology of diagnosis and analysis employed here makes it clear that the management of solid waste in an important region of the Brazilian Amazon is a great challenge. The importance given to the waste under study should nonetheless be sensitive to the people who

produce it there, while matching the flows and demands in accordance with national standards. This task is even more difficult for a region that is far from the big productive centers, often hindering reverse logistics because of the high cost of transportation and other relevant factors. Any technical alternative proposed for the system must respect the integration between the cities of the region and a more intense participation of the three levels of government.

The initial suggestion in answering the research question is to implement selective collection in the municipality, which leads to people's commitment to sending different kinds of waste to the correct destination by separating them at home or in the workplace. The installing of more collection points for batteries and the effective collection of tires and electronics would consolidate the reverse logistics proposed in the National Policy. It can be stated

that the present deficiencies are also related to the current need for more effective communication with the population, by retailing products which carry orientation strategies for their adequate disposal after use, and information on the impact of improper disposal on soil, water and air, which directly affects the health of the population.

The local analysis reveals that the municipality was concerned with the destination of the specific waste in that it requires reverse logistics but is still at fault for not meeting the general demands, for not expanding collection and destination actions, and for neglecting awareness programs for the breaking of paradigm through education. Finally, the present study recommends the formalization of local and sectoral partnerships, and the study and formulation of legal norms to define the responsibility of the municipality, the entrepreneur, and the population, including rules of conduct and punishment for inappropriate actions.

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